Migration Guide: Amazon RDS to MySQL HeatWave on Oracle Cloud Infrastructure (OCI)

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**Purpose statement**

This document provides an overview of the steps to migrate to MySQL HeatWave.

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What is MySQL HeatWave

MySQL HeatWave is a fully managed database service, powered by the integrated HeatWave in-memory query accelerator. It’s the only cloud database service that combines transactions, analytics, and machine learning services into one MySQL Database, delivering real-time, secure analytics without the complexity, latency, and cost of extract, transform, and load (ETL) duplication. It’s available on Oracle Cloud Infrastructure (OCI), Amazon Web Services (AWS), and Microsoft Azure.

MySQL HeatWave is 6.5X faster than Amazon Redshift at half the cost, 7X faster than Snowflake at one-fifth the cost, and 1,400X faster than Amazon Aurora at half the cost. With MySQL HeatWave ML, developers and data analysts can build, train, deploy, and explain machine learning models in MySQL HeatWave without moving data to a separate machine learning service. Benchmarks demonstrate that, on average, HeatWave ML produces more accurate results than Amazon Redshift ML, trains models 25X faster at 1% of the cost, and scales as more nodes are added.

Learn more about MySQL HeatWave

Before you start

1. Using the method outlined in this migration guide, where you export your source database and then import it into MySQL HeatWave, there will be some downtime involved. The length of the downtime will mostly depend on the size of your database and checks you may want to perform before bringing your database back online.

2. You should have an Amazon RDS MySQL database instance installed. To migrate using the method that is shown in this guide, you will need a source RDS MySQL instance that is running MySQL 5.7 or later. For more information, see: https://dev.mysql.com/doc/mysql-shell/8.0/en/mysql-shell-utilities-dump-instance-schema.html#mysql-shell-utilities-dump-opt-requirements

3. You can log in to the RDS MySQL instance as a SYSTEM USER. For more information, see https://dev.mysql.com/doc/mysql-security-excerpt/8.0/en/account-categories.html

4. You should have an account on Oracle Cloud Infrastructure (OCI) and be able to log in to it at https://cloud.oracle.com/.
   - If you do not have an account on OCI, you can sign-up for one at https://www.oracle.com/mysql/free/
I. Preparing your AWS environment

Section A: Prerequisites

1. As mentioned, to migrate using the method that is shown in this guide, you will need a source RDS MySQL instance that is running MySQL 5.7 or above. For this guide, we have chosen an Amazon RDS MySQL 8.0.23 (when applicable, you should always run the commands shown in this guide as a root/admin user i.e., both for your AWS environment and OCI).

You can view the Amazon RDS MySQL version that is being used for this guide in the image below:

```
+-----------------+-----------------+-------------------------+-------------------------+
| @VERSION        | east-1.rds.amazonaws | SQL > SELECT @VERSION; |
| 8.0.23          | east-1.rds.amazonaws | 1 row in set (0.0009 sec) |
+-----------------+-----------------+-------------------------+-------------------------+
```

2. To view a list of all the databases on your Amazon RDS MySQL Server and the tables in the world database, run the following commands. We will be exporting the world database from Amazon RDS MySQL to MySQL HeatWave on OCI.

```
mysql> SHOW DATABASES;
mysql> SHOW TABLES IN world;
```

For this guide, we have some data pre-loaded on our Amazon RDS MySQL database. The sample data being used for this example is called the 'world' database, which can be downloaded from here: https://dev.mysql.com/doc/index-other.html.
Section B: Create an EC2 Instance and configure your SSH keys

3. Login to your AWS account.
   https://aws.amazon.com/

4. Click on the “Services” menu and go to “Compute” > “EC2”
5. When on “EC2 Dashboard” page, look for a “Launch instance” button.
6. Click “Launch instance”. When the “Launch an instance” page opens, enter a name for your EC2 Instance. For this guide, we have chosen “MySQL-EC2”

7. For the Amazon Machine Image, choose “Red Hat” either version “Linux 8 or 9”, here we have chosen Linux
8. For “Instance type”, select one that suits your needs. Afterwards for the “Key pair” section, click on “Create new key pair”. You can also use your existing keys here.

9. When you click “Create new key pair”, a popup will appear asking you to “Create key pair”. Here, give a name for your Key pair and make sure “RSA” is selected under the “Key pair type”. Under “Private key file format”, select “.pem”.

- Note: click “Create key pair” afterwards. This will close the “Create key pair” popup and will download a private SSH Key. Look below:
10. For your “Network settings”, select your appropriate “VPC” and “Subnet”. For “Auto-assign public IP” select “Enable”. Under the “Firewall (security groups)” tab, choose “Create security group” and have an “Inbound security group rules” like the below one, which allows SSH from anywhere.
11. Once that is done, leave everything default and click “Launch instance”
12. Wait until your MySQL-EC2 “Instance state” is in “Running” before we can connect to it.

13. Once your EC2 is “Running”, open the Private SSH Key that we downloaded in Step 9 in a text editor of your choice.

14. Once you have opened your Private SSH Key in a text editor, copy the contents of the entire file like shown below:
15. After copying the contents, to connect to your EC2 instance, go to your terminal where you will be accessing EC2 from. There, create a new file called `id_rsa.pem` inside your home directory. The guide uses the “nano” text editor, use a text editor of your own choice.

```bash
$ cd
$ nano id_rsa
```

16. After pasting the contents of the private SSH key into the `id_rsa` file, save and close the file. If you are using nano,

- to paste the copied content: `command + V`
- to save the file: `control + O`
- to exit the file: `control + X`
17. After you have saved the private SSH Key on your terminal, grab the file path of the `id_rsa`. To get the file path of your current working directory where you have the `id_rsa`, run the following command:

```
$ ls
$ pwd
```

- Note: by looking at the above image, the `id_rsa` location for this guide will hence be `/Users/r***/id_rsa`
18. Once you have your SSH Key copy and pasted, make sure to change the Private SSH key's permission by running the following command:

```
$ chmod 400 id_rsa
```

19. Now try to connect to the EC2 Instance we created earlier by running the following command from your terminal window where you have the SSH keys

```
ssh -i <path/to/you-private-ssh-key> ec2-user@<ec2-Public-DNS>
```

- Note: after running the above SSH command, when prompted “Are you sure you want to continue connecting (yes/no/[fingerprint])?”, type “yes”.

20. We are now successfully connected to the EC2 instance.
Section C: Connect to your EC2 Instance and install MySQL Shell

21. Once you have identified your Amazon RDS MySQL version and the data you want to migrate, go to your AWS environment, and connect to the EC2 instance we created in Section B. It is now time to install MySQL Shell on the EC2 instance. We will be using MySQL Shell to export the world database and import it into MySQL HeatWave. (MySQL Shell is an advanced client and code editor for MySQL. To learn more about MySQL Shell, visit: https://dev.mysql.com/doc/mysql-shell/8.0/en/)

Installing MySQL Shell on Microsoft Windows:
To install MySQL Shell on Microsoft Windows using the MSI Installer, do the following:
  a) Download the Windows (x86, 64-bit), MSI Installer package from http://dev.mysql.com/downloads/shell/
  b) When prompted, click Run.
  c) Follow the steps in the Setup Wizard.

Installing MySQL Shell on Linux:
Install MySQL Shell with this command:
  a) sudo yum install mysql-shell

For other Linux installation options, visit: https://dev.mysql.com/doc/mysql-shell/8.0/en/mysql-shell-install-linux-quick.html

Installing MySQL Shell on macOS:
To install MySQL Shell on macOS, do the following:
  b) Double-click the downloaded DMG to mount it. Finder opens.
  c) Double-click the .pkg file shown in the Finder window.
  d) Follow the steps in the installation wizard.
  e) When the installer finishes, eject the DMG (It can be deleted).

This is how the guide installed MySQL Shell, visit: https://dev.mysql.com/downloads/shell/. Select the latest version of the MySQL Shell and select the appropriate OS System and Version. For this guide, Red Hat Enterprise Linux 9 server is being used for the EC2 instance.
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- Note: the **RPM Package** (28.2M), without the debug information was chosen for this guide. Once you have identified which MySQL Shell version you want to download, click on the “Download” button shown in the above image. A new page will popup which is shown in the next step.

22. When you click “Download” as shown in Step 21, this page will come up. Right click on “No thanks, just start my download.” and select “Copy Link Address”

23. Go back to your AWS EC2 instance and download MySQL Shell via *wget* by pasting the link copied in the previous step. But first, download *wget* itself:

```
$ sudo yum install wget -y
$ wget https://dev.mysql.com/get/Downloads/MySQL-Shell/mysql-shell-8.0.31-1.el8.x86_64.rpm
```

[ec2-user@ip-172-20-5-11 ~]$ sudo yum install wget -y
24. Once MySQL Shell RPM file is downloaded on your EC2 instance, extract it using

```bash
sudo rpm -ivh <file-name>
```

```console
[ec2-user@ip ~]# wget https://dev.mysql.com/get/Downloads/MySQL-Shell/mysqlshell-8.0.31-1.el8.x86_64.rpm
--2023-01-27 15:53:49--  https://dev.mysql.com/get/Downloads/MySQL-Shell/mysql-shell-8.0.31-1.el8.x86_64.rpm
Resolving dev.mysql.com (dev.mysql.com)... 96.7.17.219, 2600:1408:c400:1881::2e31, 2600:1408:c400:188c::2e31
Connecting to dev.mysql.com (dev.mysql.com)|96.7.17.219|:443... connected.
HTTP request sent, awaiting response... 302 Moved Temporarily
Location: https://dev.mysql.com//Downloads/MySQL-Shell/mysql-shell-8.0.31-1.el8.x86_64.rpm [following]
--2023-01-27 15:53:49--  https://dev.mysql.com//Downloads/MySQL-Shell/mysql-shell-8.0.31-1.el8.x86_64.rpm
Resolving cdn.mysql.com (cdn.mysql.com)... 23.56.12.246
Connecting to cdn.mysql.com (cdn.mysql.com)|23.56.12.246|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 30061380 (29M) [application/x-redhat-package-manager]
Saving to: 'mysql-shell-8.0.31-1.el8.x86_64.rpm'

2023-01-27 15:53:51 (20.7 MB/s) - 'mysql-shell-8.0.31-1.el8.x86_64.rpm' saved [30061380/30061380]
```

Note: download and install MySQL Shell by using the proper commands/files/methods required for your own Operating System.

25. To resolve the above dependency, run the following command

```bash
sudo yum install compat-openssl11
```

Once all the required dependencies are installed, run the same rpm command from Step 24

```bash
sudo rpm -ivh <file-name>
```

```console
[ec2-user@ip ~]# sudo rpm -ivh mysql-shell-8.0.31-1.el8.x86_64.rpm
warning: mysql-shell-8.0.31-1.el8.x86_64.rpm: Header V4 RSA/SHA256 Signature, key ID 3a79b929: NOKEY
error: Failed dependencies:
  libcrypto.so.1.1 (64bit) is needed by mysql-shell-8.0.31-1.el8.x86_64
  libcrypto.so.1.1 (OPENSSL_1_1_0) (64bit) is needed by mysql-shell-8.0.31-1.el8.x86_64
  libssl.so.1.1 (64bit) is needed by mysql-shell-8.0.31-1.el8.x86_64
  libssl.so.1.1 (OPENSSL_1_1_0) (64bit) is needed by mysql-shell-8.0.31-1.el8.x86_64
```

Note: there were missing dependences when the rpm command was run.

- Note: MySQL Shell was properly installed after all the dependencies were solved.
II. Exporting the database

Section D: In OCI, create an Object Storage Bucket

26. Once you have MySQL Shell installed on your EC2 instance and are ready to move data from your Amazon RDS MySQL server to MySQL HeatWave on OCI, login to your Oracle Cloud account. https://cloud.oracle.com/

27. Click on the “Hamburger” menu and go to “Storage” > “Object Storage & Archive Storage” > “Buckets”
28. To create a bucket, click “Create Bucket”. In a later step, you will export your Amazon RDS MySQL database to OCI to this bucket. (create all the resources shown in the guide in a dedicated “Compartment”, this guide uses the “ocilabs” Compartment for the creation of all resources. If you don’t have a dedicated Compartment created, you can use your “root” Compartment for all your resources. For more information about Compartments, please visit: https://docs.oracle.com/en-us/iaas/Content/Identity/Tasks/managingcompartments.htm)

29. A pop up will appear asking you to create your Bucket. Enter a “Bucket Name”, for this guide, we have chosen “Migration-Bucket”. Leave the “Default Storage Tier” as “Standard” and click “Create”
30. Once your Bucket is created and displayed on the “Buckets” page, click on your Bucket name and copy the “Namespace” value which can be found under the “General section” of “Bucket Information”

- Note: save the Bucket name as well as the Namespace value/string information into a notepad
Section E: Add an API Key and save the Configuration File

31. From the OCI Console, navigate to the top right corner where you will find a user-looking icon that says “Profile”. Click on the “Profile” icon.

![Profile Icon](image1)

- Note: the above picture is how the menu will look like once you click on the “Profile” icon.

32. Once your “Profile” menu is expanded, click on “User settings”.

![User Settings](image2)
33. Once you click on ‘User settings’, you should land on a page like the below one “Identity” > “Users” > “User Details”
34. Scroll down when you are on the above ‘User Details’ page, until you see a “Resources” section on the left-hand side. Once the ‘Resources’ section is located, click on “API Keys”

35. Once you are on the ‘API Keys’ section, click on “Add API Key”
• Note: when you click “Add API Key”, a popup will appear. On that popup:
  1) Click “Generate API Key Pair”
  2) Click “Download Private Key”
  3) Click “Download Public Key”. Save those keys for later use, you cannot download the keys later
  4) Click “Add” after you have downloaded both the Public and Private API Keys

36. Once you’ve clicked “Add” on the previous step, another popup will appear which will read “Configuration File Preview”. Select all the highlighted text under the “Configuration File Preview Read-only” section as shown in the image below and copy it. Save the copied content into a text document for later use.
• Note: click “Close” after you have saved the above “Configuration File Preview” into a notepad file. If you want to view the Configuration File again: navigate to this same API Keys page, select the appropriate ‘Fingerprint’ by looking at the ‘Date Created’. Click the three dots at the end of the selected row. Click ‘View Configuration file’. Look at the screenshot below:
Section F: Paste the Configuration File from Section E in your EC2 instance

37. Once you have created a bucket and added an API Key in OCI, go back to your AWS environment where Amazon RDS and EC2 with MySQL Shell are installed. Connect to the EC2 instance and install nano on it. (You can use a text editor of your choice here)

```bash
$ ssh -i <path/to/your-private-ssh-key> ec2-user@<ec2-Public-DNS>
ec2-user $ sudo yum install nano -y
```

38. After nano is installed on EC2, create a new directory called “.oci” inside your EC2’s home directory. Next, go into the “.oci” directory and create a file called “config”. Paste the contents of the “Configuration File Preview” that we copied in Step 36 into the newly created “config” file. The commands used to achieve this step for the guide, are listed below:

```bash
ec2-user $ mkdir ~/.oci
ec2-user $ cd .oci
ec2-user $ nano config
```
39. After the “config” file opens, paste the “Configuration File Preview” content from Step 36.

<table>
<thead>
<tr>
<th>GNU nano 2.9.8</th>
<th>config</th>
<th>Modified</th>
</tr>
</thead>
<tbody>
<tr>
<td>[DEFAULT]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>user=ocid1.user.oc1.aa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>tenancy=ocid1.tenancy.oc1.aa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>region=us-ashburn-1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>key_file=&lt;path to your private keyfile&gt; # TODO</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

40. Once you have pasted the “Configuration File Preview” snippet into the “config” file, you will need to adjust the parameter where it says “key_file” with the file path to your own OCI Private API Key. Look at an example below:

```
[DEFAULT]
user=ocid1.user.oc1.aa
tenancy=ocid1.tenancy.oc1.aa
region=us-ashburn-1
key_file=/home/ec2-user/privapikey.pem
```

- Note: If you need help uploading your Private API Key onto your EC2 instance, continue following the guide. (If you have already uploaded your API Key and have updated the “key_file” parameter for your “config” file, skip to the next Section)

41. After your new API Keys have successfully been added on OCI and you have created the “config” file on your EC2 instance, open your Private API Key in a text editor of your choice. The Private API Key will be the file without the word “public” in the file name. (You should have downloaded both the Private and Public API Keys in Step 35/36)

- **Name**
  - oracleidentitycloudservice_12-21-00-53.pem
  - oracleidentitycloudservice_12-21-00-53_public.pem
42. Once you have opened your Private API Key in a text editor, copy the contents of the entire file like shown below:

43. After copying the contents, go back to your AWS EC2 instance where you have created the “config” file and have MySQL Shell installed. Create a new file there called `privapikey.pem`, for example. This guide used the “nano” text editor to create the `privapikey.pem` file on the EC2 instance. Choose a text editor of your own choice.

```
ec2-user $ cd
ec2-user $ nano privapikey.pem
```
44. Once the `privapikey.pem` file opens up, paste the contents of the OCI Private API Key that we copied in Step 42, into this newly created `privapikey.pem` file. Save and close the file afterwards. If you are using nano,

- to paste the copied content: `command + V`
- to save the file: `control + O`
- to exit the file: `control + X`
45. After you have saved the Private API Key on your EC2 instance, grab the file path of the `privapikey.pem` and adjust the “key_file” parameter in the `.oci/config` file. To get the file path of your current working directory where you have the `privapikey.pem`, run the following command:

```bash
ec2-user $ ls
ec2-user $ pwd
```

Note: by looking at the above image, the `privapikey.pem` location for this guide will hence be `/home/ec2-user/privapikey.pem`. Go back to your `.oci` directory and adjust your `config` file accordingly.

```
[DEFAULT]
user=ocid1.user.oc1..aaa
tenancy=ocid1.tenancy.oc1..aaa
region=us-ashburn-1
key_file=/home/ec2-user/privapikey.pem
```

46. Save and close the `config` file after you have adjusted its “key_file” parameter.
Section G: Connect to your Amazon RDS MySQL Server using MySQL Shell and run the `util.dumpInstance()` utility

47. Using MySQL Shell installed on your EC2 instance, connect to your Amazon RDS MySQL Server by running the following command (from an account with Root privilege):

```
ec2-user $ mysqlsh <username>@<amazon-rds-endpoint>
```

or

```
ec2-user $ mysqlsh -u <username> -h <amazon-rds-endpoint> -P <portnumber> -p
```

Note: anytime you login using MySQL Shell, MySQL Shell will display the MySQL Shell version and MySQL Server version currently being used. You can see this in the image above.

48. Once you are inside MySQL Shell, you can interact in three different modes. The default is JavaScript, the other ones you can choose from are SQL and Python. Once inside MySQL Shell:

- to switch to JavaScript mode, run: `\js`
- to switch to SQL mode, run: `\sql`
- to switch to Python mode, run: `\py`
49. Make sure you are in JavaScript mode by typing `\js` and run the `dumpInstance` utility to export the dump data into Oracle Cloud Object Storage bucket.

```javascript
MySQL JS> \js
MySQL JS> util.dumpInstance("sampledump", {"osBucketName": "Migration-Bucket", "osNamespace": "idazzjlcqj2", "ocimds": "true", "compatibility": ["strip_restricted_grants", "strip_definers"], users: "true", dryRun:"true"})
```

Note:
- The `util.dumpInstance()` utility will take a dump of all the databases except “mysql, sys, performance schema, and information schema”. The dump comprises of DDL files for the schema structure and tab-separated .tsv files containing the actual data. Additionally, you can also use `util.dumpSchemas()` or `util.dumpTables()` if you only want to dump specific schemas or tables. The three dump utilities can export the data into:
  - a) Object Storage bucket in Oracle Cloud
  - b) S3-compatible buckets
  - c) local filesystem
- The `dryRun` option runs the export command but does not generate any output export file. It displays information about what would be dumped with the specified set of options, and about the results of MySQL HeatWave compatibility checks (if the `ocimds` option is specified, which is required for this guide), but does not proceed with the dump. Setting this option enables you to list out all the compatibility issues before starting the dump. The default is false. You can read more about the utility options at [https://dev.mysql.com/doc/mysql-shell/8.0/en/mysql-shell-utilities-dump-instance-schema.html#mysql-shell-utilities-dump-opt-control](https://dev.mysql.com/doc/mysql-shell/8.0/en/mysql-shell-utilities-dump-instance-schema.html#mysql-shell-utilities-dump-opt-control)
- In the command above, `sampledump` is the prefix under which all the exported dump files will be stored in Object Storage bucket in OCI.
- Change the `osBucketName` and `osNamespace` to match with what you have when you created your bucket in OCI in an earlier step.
- Setting the `ocimds`: `true` option ensures compatibility of the export dump with MySQL HeatWave.
- Primary keys are required on every table for using MySQL HeatWave.
50. Running the above Step 49 command may generate “Errors” regarding “table locks” (see Step 49 image). If you do encounter such problem (if and only if) run the same command as in Step 49 but this time add an additional option “consistent: false”

MySQL JS> util.dumpInstance("sampledump", {"osBucketName": "Migration-Bucket", "osNamespace": "idazzjlcqjz", "ocimds": "true", "compatibility": ["strip_restricted_grants", "strip_definers"], users: "true", dryRun:"true", consistent: "false"})

MySQL database-1. east-1.rds.amazonaws.com:3306 ssl | JS > util.dumpInstance("sampledump", {"osBucketName": "Migration-Bucket", "osNamespace": "idazzjlcqjz", "ocimds": "true", "compatibility": ["strip_restricted_grants", "strip_definers"], users: "true", dryRun:"true", consistent: "false"})
dryRun enabled, no locks will be acquired and no files will be created.
Initializing - done
1 out of 5 schemas will be dumped and within them 3 tables, 0 views.
2 out of 5 users will be dumped.
Gathering information - done
WARNING: The dumped value of gtid_executed is not guaranteed to be consistent
Checking for compatibility with MySQL Database Service 8.0.31
NOTE: User 'rdsadmin'@'localhost' had restricted privileges (CREATE TABLESPACE, FILE, RELOAD, SET_USER_ID, SHUTDOWN, SUPER, SYSTEM_USER) removed
NOTE: User 'root'@'%' had restricted privilege (RELOAD) removed
NOTE: Database 'world' had unsupported ENCRYPTION option commented out
Compatibility issues with MySQL Database Service 8.0.31 were found and repaired. Please review the changes made before loading them.
Validating MDS compatibility - done
Writing global DDL files
Writing users DDL
Writing DDL - done
Starting data dump
0% (0 rows / ~5.27K rows), 0.00 rows/s, 0.00 B/s uncompressed, 0.00 B/s compressed
MySQL database-1. east-1.rds.amazonaws.com:3306 ssl | JS >

- Note: the “table locks” error is not there anymore when consistent option is added
51. Once you have run the command in Step 49/50 and did not see any additional errors or warnings, run the same Step 49/50 command. Although, this time change the `dryRun` option to `false`.

MySQL JS> util.dumpInstance("sampledump", {"osBucketName": "Migration-Bucket", "osNamespace": "idazzjlcjqzj", "ocimds": "true", "compatibility": [{"strip_restricted_grants", "strip_definers"}, users: "true", dryRun: "false", consistent: "false"})

```
MySQL database-1 on -1.rds.amazonaws.com:3306 ssl JS > util.dumpInstance("sampledump", {"osBucketName": "Migration-Bucket", "osNamespace": "idazzjlcjqzj", "ocimds": "true", "compatibility": [{"strip_restricted_grants", "strip_definers"}, users: "true", dryRun: "false", consistent: "false"})

Initializing - done
1 out of 5 schemas will be dumped and within them 3 tables, 0 views.
2 out of 5 users will be dumped.
Gathering information - done
WARNING: The dumped value of gtid_executed is not guaranteed to be consistent
Checking for compatibility with MySQL Database Service 8.0.31
NOTE: User 'rdsadmin'@'localhost' had restricted privileges (CREATE TABLESPACE, FILE, RELOAD, SET_USER_ID, SHUTDOWN
OWN, SUPER, SYSTEM_USER) removed
NOTE: User 'root'@'%' had restricted privilege (RELOAD) removed
NOTE: Database 'world' had unsupported ENCRYPTION option commented out
Compatibility issues with MySQL Database Service 8.0.31 were found and repaired. Please review the changes made
before loading them.
Validating MDS compatibility - done
Writing global DDL files
Writing users DDL
Running data dump using 4 threads.
NOTE: Progress information uses estimated values and may not be accurate.
Writing schema metadata - done
Writing DDL - done
Writing table metadata - done
Starting data dump
100% (5.39K rows / ~5.27K rows), 0.00 rows/s, 0.00 B/s uncompressed, 0.00 B/s compressed
Dump duration: 00:00:00s
Total duration: 00:00:01s
Schemas dumped: 1
Tables dumped: 3
Uncompressed data size: 194.62 KB
Compressed data size: 91.72 KB
Compression ratio: 2.1
Rows written: 5380
Bytes written: 91.72 KB
Average uncompressed throughput: 194.62 KB/s
Average compressed throughput: 91.72 KB/s
```

• Note: once the dump process is complete, MySQL Shell will display a summary of the dump process like the one shown in the image above.
III. Importing the database

Section H: Navigate to the Object Storage bucket to confirm if the dump was successful

52. Go back to your Oracle Cloud Object Storage bucket created in Step 30 and locate the dump files under the `sampledump` prefix.
Section I: Create a VCN and adjust the Security List

53. From the OCI Console, click on the “Hamburger” menu, but this time go to “Networking” > “Virtual Cloud Networks”

54. Once on the “Virtual Cloud Networks” page, click on “Start VCN Wizard”

- Note: a popup will appear saying “Start VCN Wizard”. Choose the “Create VCN with Internet Connectivity” option and click “Start VCN Wizard”
55. Give a name to your VCN, we have chosen Migration-VCN for this guide. Leave everything default, and click “Next”.

56. You will be on “Review and Create” page after the previous step. Review your VCN information and click “Create”.
57. Once all the Resources for your VCN have been created, click on “View Virtual Cloud Network”

58. You will land on the “Virtual Cloud Network Details” page. From here, locate your “Private Subnet” under the “Subnets” section
59. Click on the “Private Subnet” from the above screen. A “Subnet Details” page will open up that will say “Private Subnet-<VCN-Name>”.

60. Scroll down on the above page until you see a “Security Lists” section. Click on “Security List for Private Subnet-<VCN-Name>”
61. On the Security List for Private Subnet page, click “Add Ingress Rules”

62. A popup will appear, for “Source CIDR” enter 0.0.0.0/0
   - Leave the IP Protocol as TCP, and Source Port Range as blank. For the “Destination Port Range” enter 3306,33060
   - For Description, you can write “MySQL Port Access”. Click “Add Ingress Rules” afterwards (Note: it is not recommended to use 0.0.0.0/0 Source CIDR for your production system)
63. Your Ingress Rules should look like those on the image below

<table>
<thead>
<tr>
<th>Stateless</th>
<th>Source</th>
<th>IP Protocol</th>
<th>Source Port Range</th>
<th>Destination Port Range</th>
<th>Type and Code</th>
<th>Allows</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>10.0.0.0/16</td>
<td>TCP</td>
<td>All</td>
<td>22</td>
<td></td>
<td></td>
<td>TCP traffic for port 22 (SSH) remote login protocol</td>
</tr>
<tr>
<td>No</td>
<td>0.0.0.0/0</td>
<td>ICMP</td>
<td>S, 4</td>
<td></td>
<td></td>
<td></td>
<td>ICMP traffic for S, 4 (Destination Unreachable)</td>
</tr>
<tr>
<td>No</td>
<td>10.0.0.0/16</td>
<td>ICMP</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td>ICMP traffic for port 0 (Destination Unreachable)</td>
</tr>
<tr>
<td>No</td>
<td>0.0.0.0/0</td>
<td>TCP</td>
<td>All</td>
<td>3306</td>
<td></td>
<td></td>
<td>TCP traffic for port 3306 (MySQL Port Access)</td>
</tr>
<tr>
<td>No</td>
<td>0.0.0.0/0</td>
<td>TCP</td>
<td>All</td>
<td>3306</td>
<td></td>
<td></td>
<td>TCP traffic for port 3306 (MySQL Port Access)</td>
</tr>
</tbody>
</table>
Section J: Create a Compute Instance and configure your SSH keys

64. From the OCI Console, click on the “Hamburger” menu again, and navigate to “Compute” > “Instances”

65. Click on “Create instance” when on the “Instances” page

66. Give your Compute Instance (VM) a name. We have chosen “MySQL-Compute” for this guide
67. Scroll down until you see an “Image and shape” section. Under “Image” make sure “Oracle Linux 8” is selected and for the “Shape”, select one that suits your needs. (Standard.E4.Flex recommended. This Compute Instance will be used to connect to the MySQL HeatWave instance and later to demonstrate MySQL Shell loadDump). Remember: The dumpInstance and loadDump speed depends on the number of OCPUs/vCPUS and the amount of the data that is being migrated)

68. Once the Image and Shape are selected, scroll down until you see the “Networking” section. Make sure you have the right Compartment and the VCN that we created earlier selected (the guide used “Migration-VCN”). Also make sure that “Public Subnet” is selected under the Subnet option.
69. Finally, scroll down until you see the “Add SSH keys” section. You can either generate a pair of new SSH keys, upload your own public key file, or paste it. The guide uses “Paste public keys” options since we already had an SSH Key pair downloaded.

- Note: after you have created/added your SSH keys, click “Create”. Refer to Section P of this guide if you need instructions on how to generate a new SSH key pair and then use that to login into your Compute Instance.

70. Your Compute will soon be in an “ACTIVE” state afterwards

- Note: you can SSH into the Compute Instance by running the following command:

```bash
ssh -i <path/to/you-private-ssh-key> opc@<compute-public-ip-address>
```
**Section K: Create a MySQL HeatWave System and import the dumped data using PAR URL**

71. Once all the dump files have successfully been exported to the Object Storage Bucket, in OCI click on the “Hamburger” menu and go to “Databases” > “MySQL”

![Databases menu and Create DB System button](image1.png)

72. Once on the MySQL DB Systems page, click “Create DB System”

![Create DB System button](image2.png)
73. A new page will appear. Here, give a name to your MySQL DB System and select the “HeatWave” option:

- Note: after selecting “HeatWave”, create your Administrator credentials that will be used to manage the MySQL HeatWave database.
74. After creating the Administrator credentials, configure your Networking. Choose the VCN we created earlier (this guide uses Migration-VCN) and make sure the “Private Subnet” is selected.

75. For “Configure Placement” leave it as default. Afterwards, configure your DB hardware by choosing an appropriate HeatWave DB Shape. For the Data Storage Size it is the size of your database. Be sure to make the size large enough for future growth.
76. Next, choose a “Backup Plan”.

77. Once your Backup Plan is configured, lastly scroll down until you see “Show advanced options”. Click on it to expand.
- Note: from the above screen, go to the “Data Import” tab.

78. On the “Data Import” tab, click on ‘Click here to create a PAR URL for an existing bucket’.

- Note: this will open a pop up which will look like below:
• Note: to learn what Pre-Authenticated Request (PAR) is, refer to: https://docs.oracle.com/en-us/iaas/Content/Object/Tasks/usingpreauthenticatedrequests.htm

79. From the “Create PAR for existing bucket” screen, under “Select a bucket in <compartment-name>”, choose the bucket we created in Step 30. Specify an appropriate PAR expiration time once the bucket is selected.

• Note: once the bucket is selected, make sure the right Prefix is also selected if you had one, under “Configure prefix”. The prefix we used was sampledump
Note: click "Create and set PAR URL" once you have chosen the appropriate bucket, prefix, and expiration time for the PAR.

80. Once you have finished Step 79, the “PAR Source URL” field will automatically be populated by the URL. Click “Create” afterwards.

Note: using the “Data Import” “PAR Source URL” option, your data stored in OCI Object Storage bucket will automatically start loading while your MySQL DB System is creating. Once the MySQL DB System is “ACTIVE”, the data that was imported using the PAR URL will also be present, which we will see in the later steps.
81. Once you click Create in Step 80, your MySQL DB System will start “CREATING”:

- Note: your MySQL DB System State will change from CREATING TO “ACTIVE” once the DB System is ready.

82. Once your MySQL DB System is ACTIVE, a “Private IP Address” will be allocated to it, find it and copy it. You can find this Private IP under “DB System Information” > “Endpoint” section on the “DB System Details” page.
• Note: you can navigate to the “DB System Details” page by going to the “Hamburger” menu in OCI. “Databases” > “MySQL” > “DB Systems”. Click on the name of your MySQL DB System to open the “DB System Details” page.

• Note: copy the Private IP Address. You can now login to your MySQL DB System using MySQL Shell. Run:
  
  ```bash
  $ mysqlsh <username>@<private-mysql-ip>
  
  Or
  $ mysqlsh -u <username> -h <private-mysql-ip> -P <portnumber> -p
  ```
Section L: Connect to your Compute Instance and install MySQL Shell

83. Next, SSH into the Compute Instance we created in Step 70.

```bash
ssh -i <path/to/you-private-ssh-key> opc@<compute-public-ip-address>
```

```
Last login: Fri Jan 27 18:00:20 on ttys001

r@compute-instance-mac % ssh -i .ssh/id_rsa opc@
```

Activate the web console with: systemctl enable --now cockpit.socket

```
Last login: Fri Jan 27 15:11:39 2023 from <compute-instance-public-ip-address>
```

84. Install MySQL Shell on the Compute Instance after SSHing into it. On the terminal run the following command:

```bash
$ sudo yum install mysql-shell -y
```

Note: once MySQL Shell is successfully installed, you should see a "Complete!" message on your terminal like the one shown in the image below:
Section M: Connect to your MySQL HeatWave System and verify if the data was imported successfully

85. Once MySQL Shell is installed on the Compute Instance, verify if your data was successfully imported into the MySQL HeatWave system. Using MySQL Shell, login to MySQL HeatWave via the Private IP

```bash
$ mysqlsh <username>@<private-mysql-ip>
```

or

```bash
$ mysqlsh -u <username> -h <private-mysql-ip> -P <portnumber> -p
```

86. Once logged in, switch to ‘SQL’ mode and run the command: SHOW SCHEMAS

```sql
MySQL JS> \sql
MySQL SQL> SHOW SCHEMAS;
```
IV. Loading data into MySQL HeatWave

Section N: Create a HeatWave Cluster

To make use of MySQL HeatWave’s in-memory query engine and query acceleration capabilities, you need to attach a HeatWave cluster to your MySQL Database on OCI.

87. From your OCI Home Page, click the ‘Hamburger’ menu and go to “Databases” > “MySQL”. Once on the MySQL page, click on the name of your MySQL HeatWave System.

Note: clicking on the name of your MySQL System will open the “DB System Details” page.
88. Once on “DB System Details” page, click on “More actions” and select “Add HeatWave cluster”

89. After finishing Step 88, a new page will open that will say “Add HeatWave cluster”. On this page, click on “Estimate node”

- Note: Based on your database size, the next steps will estimate the size of the HeatWave cluster you will need to load the data into memory and run queries. The number of nodes in MySQL HeatWave on OCI can scale up to 64. Each node can handle approximately 800 GB of data.
90. Once you click on “Estimate node”, an “Estimate node” screen will appear that will look like the below image:

91. Here, click on “Generate estimate”. This will show you a list of all the databases that you have in your MySQL HeatWave system. Afterwards, you can select what tables and databases you want to load in-memory, from the list of databases that will appear after clicking “Generate estimate”.

- Note: once you click on “Generate estimate”, it may take several minutes to display your schema information.
92. This is what our screen looked like after hitting “Generate estimate”. It pulled up all the database schemas that we currently have in MySQL.

![Estimate node](image)

93. From the above screen, you can either select the entire database/s or select individual tables that you want to load in-memory.

![Estimate node](image)
94. After you are done selecting the tables/databases you want to load in-memory, on that same screen, scroll down

- Note: instead of loading the whole database, for this guide we will only load the two tables (city and countrylanguage)

- Note: The end of that page shows us a summary on how many nodes will be required depending on the data we have selected (in our case as you can see, only need 1 node was needed and 6 MB of memory will be used)
95. On the same page, there is a section that says “Load command”. Simply copy that line of code and keep it aside. In the upcoming steps we will take the copied command and run it inside our MySQL HeatWave system, which will automatically load the selected data into memory using parallelism.

- Note: after copying the command, click “Apply estimated node”. This will change the number of nodes required to load the data that you have selected (depending on the data size).

- Note: after your node count has been updated, click “Add HeatWave Cluster” to finish adding the HeatWave cluster process.
96. After clicking “Add HeatWave cluster”, you can see the status of the Cluster change to “Creating” on the “DB System Details” page.

- Note: to track how far along is the Cluster creation process, simply scroll down on that same page and look for “Work Requests” under the Resources section on the left.

97. Once the HeatWave Cluster is created and “ACTIVE”, this is what it should look like.

- Note: notice the “Cluster state: ACTIVE” status.
Section O: Load data into the HeatWave Cluster

98. Now it is time to login back into our MySQL HeatWave system and load the data into memory. Login to your Compute instance with MySQL Shell installed to connect to MySQL HeatWave

```bash
ssh -i <path/to/you-private-ssh-key> opc@<compute-public-ip-address>
```

then,

```bash
$ mysqlsh <username>@<private-mysql-ip>
```

or

```bash
$ mysqlsh -u <username> -h <private-mysql-ip> -P <portnumber> -p
```

99. Once logged in, change the MySQL Shell mode to `\sql` and run the command we copied in Step 95 to load the data in-memory

```sql
MySQL JS> \sql
MySQL SQL> CALL sys.heatwave_load(JSON_ARRAY('world'), JSON_OBJECT('exclude_list', JSON_ARRAY('world.country')));
```

(replace the load command with what you have)
100. Once you invoke that command, MySQL HeatWave will automatically load all your data without any user intervention. This is what the screen looks like:

```
MySQL> CALL sys.heatwave_load(JSON_ARRAY('world'), JSON_OBJECT('exclude_list', 'world.country'));

<table>
<thead>
<tr>
<th>INITIALIZING HEATWAVE AUTO PARALLEL LOAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Version: 1.39</td>
</tr>
<tr>
<td>Load Mode: normal</td>
</tr>
<tr>
<td>Load Policy: disable_unsupported_columns</td>
</tr>
<tr>
<td>Output Mode: normal</td>
</tr>
</tbody>
</table>

6 rows in set (0.5811 sec)

OFFLOAD ANALYSIS

Verifying input schemas: 1
User excluded items: 1

<table>
<thead>
<tr>
<th>SCHEMA NAME</th>
<th>OFFLOADABLE TABLES</th>
<th>OFFLOADABLE COLUMNS</th>
<th>SUMMARY OF ISSUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>world</td>
<td>2</td>
<td>9</td>
<td>1 table(s) are excluded by user</td>
</tr>
</tbody>
</table>

10 rows in set (0.5811 sec)

- Note: on the above image you can see that HeatWave tells us that 2 tables will be loaded in-memory and we have excluded one of the tables.

```

```

CAPACITY ESTIMATION

Default load pool for tables: TRANSACTIONAL
Default encoding for string columns: VALEN (unless specified in the schema)
Estimating memory footprint for 1 schema(s)

<table>
<thead>
<tr>
<th>SCHEMA NAME</th>
<th>TOTAL OFFLOADABLE TABLES</th>
<th>ESTIMATED HEATWAVE NODE FOOTPRINT</th>
<th>ESTIMATED MYSQL NODE FOOTPRINT</th>
<th>TOTAL STRING COLUMNS</th>
<th>DICTIONARY ENCODED COLUMNS</th>
<th>VALEN ENCODED COLUMNS</th>
<th>ESTIMATED LOAD TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>world</td>
<td>2</td>
<td>6.11 MIB</td>
<td>784.00 KiB</td>
<td>5</td>
<td>0</td>
<td>5</td>
<td>1.00 s</td>
</tr>
</tbody>
</table>

Sufficient MySQL host memory available to load all tables.
Sufficient HeatWave cluster memory available to load all tables.

13 rows in set (0.5811 sec)

- Note: on that same screen, HeatWave also tells us how much memory will be consumed after the data has loaded, alongside some other useful information.

```
101. You now have a complete MySQL HeatWave cluster.

102. Congratulations, you’ve now successfully migrated your data from Amazon RDS MySQL to MySQL HeatWave on OCI!

To learn more about using HeatWave, please visit our documentation.
V. Appendix

Section P: Create a new SSH Key pair and connect to your Compute Instance

103. In OCI, go to “Identity” > “Users” > “User Details” page and create your Compute Instance (refer to Section 1 of this guide on how to get to that page). Give your Compute Instance (VM) a name. We have chosen “MySQL-Compute” for this guide.

![Create compute instance](image1)

104. Scroll down until you see an “Image and shape” section. Under “Image” make sure “Oracle Linux 8” is selected and for the “Shape”, select one that suits your needs. (Standard.E4.Flex recommended. This Compute Instance will be used to connect to the MySQL HeatWave instance and later to demonstrate MySQL Shell loadDump). Remember: The dumpInstance and loadDump speed depends on the number of OCPUs/vCPUs and the amount of the data that is being migrated.

![Create compute instance](image2)
105. Once the Image and Shape are selected, scroll down until you see the “Networking” section. Make sure you have the right Compartment and the VCN that we created earlier selected (the guides used “Migration-VCN”). Also make sure that the “Public Subnet” is selected under the Subnet option.

106. Lastly, scroll down until you see “Add SSH keys” section. Make sure “Generate a key pair for me” is selected and download both the “private key” and “public key”.
107. Click “Create” once you have your SSH keys downloaded. Your Compute will then start PROVISIONING and will be in a “RUNNING” state within a few minutes.

108. Once your Compute is RUNNING, open the private SSH key in a text editor of your choice. The private SSH key will be the one with the “.key” extension at the end.
109. Once you have opened your private SSH Key in a text editor, copy the contents of the entire file like shown below:

![SSH Key Image]

110. After copying the contents, go back to your terminal window from which you will be able to SSH into the newly created Compute Instance. For this guide, we have chosen an Oracle Linux machine for SSHing into the “MySQL-Compute” Compute Instance.

```
[opc@oraclelinux8 ~]$
```

111. On your terminal, inside your home directory, create a new “.ssh” directory. Once the directory is created, go inside that directory. If you already have a .ssh directory, just go inside that directory.

```
oraclelinux8 $ cd
oraclelinux8 $ mkdir .ssh
oraclelinux8 $ cd .ssh
```

```
[opc@oraclelinux8 ~] cd
[opc@oraclelinux8 ~]$
[opc@oraclelinux8 ~] mkdir .ssh
[opc@oraclelinux8 ~]$
[opc@oraclelinux8 ~] cd .ssh
[opc@oraclelinux8 .ssh]$
```
112. Once inside the “.ssh” directory, create a new file called `id_rsa` and paste the contents of the private SSH key into the newly created `id_rsa` file. The guide uses “nano” text editor, use a text editor of your own choice.

```
oraclelinux8 $ nano id_rsa
```

113. After pasting the contents of the private SSH key into the `id_rsa` file, save and close the file. If you are using nano,

- to paste the copied content: `command + V`
- to save the file: `control + O`
- to exit the file: `control + X`
114. After you have saved the private SSH Key on your terminal window, grab the file path of the `id_rsa`. To get the file path of your current working directory where you have the `id_rsa`, run:

```
oraclelinux8 $ ls
oraclelinux8 $ pwd

[opc@oraclelinux8 .ssh]$ ls
id_rsa
[opc@oraclelinux8 .ssh]$ pwd
/home/opc/.ssh

[opc@oraclelinux8 .ssh]$ ...
```

*Note: by looking at the above image, the `id_rsa` location for this guide will hence be `/home/opc/.ssh/id_rsa`

115. Once you have your SSH Key copy and pasted, make sure to change the Private SSH key's permission by running the following command:

```
oraclelinux8 $ chmod 400 id_rsa

[opc@oraclelinux8 .ssh]$ chmod 400 id_rsa
```

116. Now connect to the Compute Instance we created earlier by running the following command from your terminal window where you have the SSH keys

```
ssh -i <path/to/you-private-ssh-key> opc@<compute-public-ip-address>

[opc@oraclelinux8 ~]$ ssh -i .ssh/id_rsa opc@

Activate the web console with: systemctl enable --now cockpit.socket

[opc@mysql-compute ~]$
```
Section Q: Connect to your Compute Instance using MySQL Shell and run the util.loadDump() utility

117. This guide showcased how you can import your data from an Object Storage bucket into MySQL HeatWave on OCI using PAR URL, which will import the data while the MySQL HeatWave System is creating. But if you want to load your data after the MySQL HeatWave System is created, the alternate method of loading the data into your MySQL HeatWave database is to use MySQL Shell loadDump() utility.

To use the MySQL Shell dump utility, we will need to first drop the “world” database we imported using the PAR URL in the earlier step. Login to your Compute instance with MySQL Shell installed to connect to MySQL HeatWave

```
ssh -i <path/to/your-private-ssh-key> opc@<compute-public-ip-address>
```

then,

```
mysql-compute $ mysqlsh <username>@<private-mysql-ip>
```

or

```
mysql-compute $ mysqlsh -u <username> -h <private-mysql-ip> -P <portnumber> -p
```

118. Once you are connected to MySQL HeatWave, perform a DROP DATABASE and exit out of MySQL Shell

```
MySQL JS> \sql
MySQL SQL> DROP DATABASE world;
MySQL SQL> \q
```

```
<table>
<thead>
<tr>
<th>Database</th>
</tr>
</thead>
<tbody>
<tr>
<td>information_schema</td>
</tr>
<tr>
<td>mysql</td>
</tr>
<tr>
<td>performance_schema</td>
</tr>
<tr>
<td>sys</td>
</tr>
</tbody>
</table>

4 rows in set (0.0014 sec)
119. After exiting MySQL HeatWave and MySQL Shell, from the command line of your OCI Compute Instance verify that you are in your home directory. Create a directory named .oci. Next, go into the .oci directory and create a file called config. Paste the contents of the “Configuration File Preview” we copied in Step 36 into the newly created config file. The commands used to achieve this step for the guide are listed below:

```
mysql-compute $ mkdir ~/.oci
mysql-compute $ cd .oci
mysql-compute $ nano config
```

120. After the “config” file opens, paste the “Configuration File Preview” content from Step 36

```
[DEFAULT] nano 2.9.8
config

[DEFAULT]
user=ocid1.user.oc1..aaa
tenancy=ocid1.tenancy.oc1..aaa
region=us-ashburn-1
key_file=<path to your private keyfile> # TODO
```

121. Once you have pasted the “Configuration File Preview” snippet into the “config” file, you will need to adjust the parameter where it says “key_file” with the file path to your own OCI Private API Key. Look at an example below:

```
[DEFAULT] nano 2.9.8
config

[DEFAULT]
user=ocid1.user.oc1..aaa
tenancy=ocid1.tenancy.oc1..aaa
region=us-ashburn-1
key_file=/home/opc/privapikey.pem
```

- Note: If you need help uploading your Private API Key onto your Compute Instance, the steps are as follows
122. Open your Private API Key that we downloaded in Step 35 in a text editor of your choice. The Private API Key will be the file without the word “public” in the file name.

123. Once you have opened your Private API Key in a text editor, copy the contents of the entire file as shown below:

124. After copying the contents, go back to your Compute Instance on OCI where you have created the “config” file and have MySQL Shell installed. Create a new file there called privapikey.pem, for example. This guide used the “nano” text editor to create the privapikey.pem file on the Compute Instance. Choose a text editor of your own choice.

```bash
mysql-compute $ cd
mysql-compute $ nano privapikey.pem
```

```bash
[opc@mysql-compute ~]$ nano privapikey.pem
```
125. Once the `privapikey.pem` file opens, paste the contents of the OCI Private API Key that we copied in Step 123, into this newly created `privapikey.pem` file. Save and close the file afterwards. If you are using nano,

- to paste the copied content: command + V
- to save the file: control + O
- to exit the file: control + X

126. After you have saved the Private API Key on your OCI Compute Instance, grab the file path of the `privapikey.pem` and adjust the “key_file” parameter in the `.oci/config` file. To get the file path of your current working directory where you have the `privapikey.pem`, run the following command:

```bash
mysql-compute $ ls
mysql-compute $ pwd
```

- Note: by looking at the above image, the `privapikey.pem` location for this guide will hence be `/home/opc/privapikey.pem`. Adjust your config file accordingly.
After completing the above steps, you are now ready to load the dump data from the Object Storage Bucket into MySQL HeatWave using MySQL Shell. Log back into your MySQL HeatWave system using the Compute Instance where we have created the “config” file and have MySQL Shell installed.

```bash
mysql-compute $ mysqlsh <username>@<private-mysql-ip>
```

or

```bash
mysql-compute $ mysqlsh -u <username> -h <private-mysql-ip> -P <portnumber> -p
```
It is now time to load our sample database “world”, which we dumped from our Amazon RDS MySQL to the Oracle Cloud Object Storage. Inside MySQL Shell, make sure you are in the JavaScript mode of MySQL Shell by running \js and then, run the `loaddump` utility to import the dumped data from the Oracle Cloud Object Storage bucket into MySQL HeatWave.

```sql
MySQL SQL> \js
MySQL JS> util.loadDump("sampledump", {osBucketName: "Migration-Bucket",
    osNamespace: "ixxxxxxxj", progressFile: "/home/opc/progressfile.json",
    ignoreVersion: "true", loadUsers: "true", dryRun: "true"})
```

Note:
- The `util.loadDump()` utility will use the DDL files and tab-separated .tsv data files to set up the server instance or schema in the target MySQL instance, then loads the data. For more information, refer to: [https://dev.mysql.com/doc/mysql-shell/8.0/en/mysql-shell-utilities-load-dump.html](https://dev.mysql.com/doc/mysql-shell/8.0/en/mysql-shell-utilities-load-dump.html)
- Change the prefix, `osBucketName` and `osNamespace` to match with what you have.
129. Once you have run the command in Step 128 and did not see any errors or warnings, run the same command as in Step 128. This time change the dryRun option to false:

```
```

- Note: once the load process is complete, MySQL Shell will display a summary of the dump process similar to the one shown in the image above.

130. After your import command has completed successfully in the previous step, you can verify the schemas and tables imported by running the following commands in \sql mode:

```
MySQL JS> \sql
MySQL SQL> SHOW SCHEMAS;
MySQL SQL> SHOW TABLES IN world;
```
Section R: Performing the util.dumpInstance() and util.loadDump() utility to and from a local filesystem

131. For relatively small databases, you can create the dump files on your local system. Although, you need to transfer them to the OCI Compute instance using the copy utility of your choice, depending on the operating system you chose for your Compute instance. (MySQL Shell must be installed on the systems from where you intend to run the util.dumpInstance() and util.loadDump() utility, setting up the config file is not required here)

132. In this Section, we will showcase how to perform the dumpInstance() utility from the Amazon RDS MySQL instance into a local filesystem. The local filesystem used for the dumpInstance() in this guide is the EC2 instance that we had provisioned earlier.

133. Connect to your Amazon RDS MySQL instance using MySQL Shell.

```bash
ec2-user $ mysqlsh <username>@<amazon-rds-endpoint>
```

or

```bash
ec2-user $ mysqlsh -u <username> -h <amazon-rds-endpoint> -P <portnumber> -p
```

```
Please provide the password for 'root@database-1.us-east-1.rds.amazonaws.com': ***
*****

Save password for 'root@database-1.us-east-1.rds.amazonaws.com'? [Y]es/[N]o/[E]nter/[V]iew: [Y]
```

MySQL Shell 8.0.31

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Type ‘\help’ or ‘\?’ for help; ‘\quit’ to exit.
Creating a session to 'root@database-1.us-east-1.rds.amazonaws.com'
Fetching schema names for auto-completion... Press ^C to stop.
Your MySQL connection id is 26
Server version: 8.0.23 Source distribution
No default schema selected; type \use <schema> to set one.

MySQL database-1.us-east-1.rds.amazonaws.com:3306 ssl js >
134. Make sure you are in JavaScript mode by typing `\js` and run the `dumpInstance` utility to export the dump data into your local filesystem.

```
MySQL JS> \js
MySQL JS> util.dumpInstance("/home/ec2-user/sampledump", {"ocimds": "true", "compatibility": ["strip_restricted_grants", "strip_definers"], users: "true", dryRun:"true", consistent: "false")
```

Note:
- `/home/ec2-user/sampledump` is the outputUrl. Here, you can specify an absolute path or a path relative to the current working directory for your local filesystem.
- `sampledump` is the directory under which all the exported dump files will be stored in EC2. The `sampledump` directory must not exist or if it does, the directory should be empty.
- Use the `consistent: false` option, if and only if, your `dump` utility produces “Errors” regarding “table locks” (See Steps 49/50 for more information).
- The `util.dumpInstance()` utility will take a dump of all the databases except “mysql, sys, performance schema, and information schema”. The dump comprises of DDL files for the schema structure and tab-separated .tsv files containing the actual data. Additionally, you can also use `util.dumpSchemas()` or `util.dumpTables()` if you only want to dump specific schemas or tables. The three dump utilities can export the data into:
  - a) Object Storage bucket in Oracle Cloud
  - b) S3-compatible buckets
  - c) local filesystem
- This Section showcases option c). For more information, refer: https://dev.mysql.com/doc/mysql-shell/8.0/en/mysql-shell-utilities-dump-instance-schema.html#mysql-shell-utilities-dump-opt-run
- The `dryRun` option runs the export command but does not generate any output export file. It displays information about what would be dumped with the specified set of options, and about the results of MySQL HeatWave compatibility checks (if the `ocimds` option is specified, which is required for this guide), but does not proceed with the dump. Setting this option enables you to list out all the compatibility issues before starting the dump. The default is false. You can read more about the utility options at https://dev.mysql.com/doc/mysql-shell/8.0/en/mysql-shell-utilities-dump-instance-schema.html#mysql-shell-utilities-dump-opt-control
- Setting the `ocimds: true` option ensures compatibility of the export dump with MySQL HeatWave.
- Primary keys are required on every table for using MySQL HeatWave.
If you can't seem to solve an error during the dryRun, contact a MySQL Solution Engineer for guidance: https://go.oracle.com/LP=132857?src1=ow:os:po::&intcmp=ow:os:po::

To understand the dumpInstance(), dumpSchemas(), or dumpTables() utility in more detail, refer to this website: https://dev.mysql.com/doc/mysql-shell/8.0/en/mysql-shell-utilities-dump-instance-schema.html

135. Once you have run the command in Step 134 and did not see any additional errors or warnings, run the same command as in Step 134. This time change the dryRun option to false:

```sql
MySQL JS> util.dumpInstance("/home/ec2-user/sampledump", {"ocimds": "true", "compatibility": ["strip_restricted_grants", "strip_definers"], users: "true", dryRun:"false", consistent: "false"})
```

Note: once the dump process is complete, MySQL Shell will display a summary of the dump process like the one shown in the image above.

- Note: once the dump process is complete, MySQL Shell will display a summary of the dump process like the one shown in the image above.
136. Go back to your local filesystem and locate the dump files under the `sampledump` directory, to confirm if the dump was successful (in our case, the EC2 instance).

```bash
[ec2-user@i-] ~]$ ls
mysqlshell-8.0.31-1.el8.x86_64.rpm privapikey.pem sampledump world-db world-db.zip
[ec2-user@ip-] ~]$ cd sampledump
[ec2-user@ip- sampledump]$ ls
.done.json    world@city.json    world@countrylanguage.json
.json         world@city.sql     world@countrylanguage.sql
.post.sql     world@country@@@.tsv.zst world@country@@@.tsv.zst.idx world@country@@@.tsv.zst.idx
.sql          world@country@@@.tsv.zst idx world@country@@@.tsv.zst idx
.users.sql    world@countrylanguage@@@.tsv.zst
world@city@@@.tsv.zst.idx world@countrylanguage@@@.tsv.zst.idx
[ec2-user@ip- sampledump]$ 
```

137. Now, transfer the `sampledump` directory to the OCI Compute instance using the copy utility of your choice, depending on the operating system you chose for your Compute instance. One way to do this is to use the `scp` command.

138. After you have copied over your `sampledump` directory to the OCI Compute instance, login to that Compute instance and retrieve the path to the `sampledump` directory.

```bash
ssh -i <path/to/you-private-ssh-key> opc@<compute-public-ip-address>
```

```
[opc@mysql-compute ~]$ ls
privapikey.pem sampledump
[opc@mysql-compute ~]$ ls
[opc@mysql-compute ~]$ pwd
/home/opc
[opc@mysql-compute ~]$
```

- Note: by looking at the above image, the `sampledump` directory location for this guide will hence be `/home/opc/sampledump`
139. Login to that Compute instance, and then login to your MySQL HeatWave instance using MySQL Shell to load those dump files.

```bash
ssh -i <path/to/you-private-ssh-key> opc@<compute-public-ip-address>
```

then,

```bash
mysql-compute $ mysqlsh <username>@<private-mysql-ip>
```

or

```bash
mysql-compute $ mysqlsh -u <username> -h <private-mysql-ip> -P <portnumber> -p
```

140. It is now time to load our sample database “world” that we dumped from our Amazon RDS MySQL to the local filesystem in EC2, which we later transferred to the OCI Compute instance using the copy utility of your choice. Inside MySQL Shell, make sure you are in JavaScript mode of MySQL Shell by running `\js` and then, run the loaddump utility to import the dumped data from Oracle Cloud Compute instance into MySQL HeatWave.

```bash
MySQL SQL> \js
```

Opening dump... dryRun enabled, no changes will be made.
Target is MySQL 8.0.31-u3-cloud (MySQL Database Service). Dump was produced from MySQL 8.0.23
Scanning metadata - done
Checking for pre-existing objects...
Executing common preamble SQL
Executing DDL - done
Executing view DDL - done
Starting data load
Executing user accounts SQL...
NOTE: Skipping CREATE/ALTER USER statements for user 'root'@"%
NOTE: Skipping GRANT statements for user 'root'@"%
Executing common postamble SQL
% (0 bytes / 194.62 KB), 0.00 B/s, 3 / 3 tables done
Recreating indexes - done
No data loaded.
0 warnings were reported during the load.
141. Once you have run the command as in Step 140 and did not see any errors or warnings, run the same command as in Step 140. This time change the dryRun option to false:

```
```

Note: once the load process is complete, MySQL Shell will display a summary of the dump process like the one shown in the image above.

142. After your import command has completed successfully in the previous step, you can verify the schemas and tables imported by running the following commands in `\sql` mode:

```
MySQL JS> \sql
MySQL SQL> SHOW SCHEMAS;
MySQL SQL> SHOW TABLES IN world;
```

Note: the image shows the output of the `SHOW SCHEMAS` and `SHOW TABLES` commands.